CLAIMS

What is claimed is:

1. A resonant optical modulator, comprising:
   a) a transmission optical waveguide adapted for transmitting therethrough an optical signal, the transmission optical waveguide having a transverse coupling segment;
   b) a resonant optical component including at least one circumferential-mode optical resonator, the circumferential-mode optical resonator being positioned so as to be transverse-coupled to the transmission optical waveguide at the transverse-coupling segment thereof, the resonant optical component being substantially resonant with the optical signal;
   c) a modulator optical component, the modulator optical component being positioned so as to be transverse-coupled to the circumferential-mode optical resonator; and
   d) a modulator control component, the modulator control component being operatively coupled to the modulator optical component, the modulator optical component and the modulator control component being adapted for modulating, in response to an applied control signal, at least one of i) a level of optical signal power transfer by transverse-coupling between the circumferential-mode optical resonator and the modulator optical component, ii) a level of optical loss of the modulator optical component, and iii) a resonant frequency of the modulator optical component,

   the modulator control component thereby enabling controlled modulation of a coupling condition between the transmission optical waveguide and the resonant optical component, in turn enabling controlled modulation of a level of transmission of the optical signal through the transmission optical waveguide between a higher operational optical transmission level and a lower operational optical transmission level.
2. The resonant optical modulator of Claim 1, the modulator optical component comprising a modulator optical waveguide.
3. The resonant optical modulator of Claim 2, the modulator optical waveguide being positioned tangentially with respect to the circumferential-mode optical resonator for transverse-coupling thereto.
4. The resonant optical modulator of Claim 3, the modulator optical waveguide comprising a slab waveguide.

5. The resonant optical modulator of Claim 3, the modulator optical waveguide comprising a laterally-confined optical waveguide.
6. The resonant optical modulator of Claim 3, the modulator optical waveguide comprising a protruding ridge optical waveguide.
7. The resonant optical modulator of Claim 2, the modulator optical waveguide being positioned axially relative to the circumferential-mode optical resonator for transverse-coupling thereto.
8. The resonant optical modulator of Claim 7, the circumferential-mode optical resonator comprising a fiber-ring optical resonator.
9. The resonant optical modulator of Claim 7, further including a spacer positioned between the circumferential-mode optical resonator and the modulator optical waveguide.
10. The resonant optical modulator of Claim 1, the modulator optical component comprising a modulator optical resonator.
11. The resonant optical modulator of Claim 10, the modulator optical resonator being positioned tangentially with respect to the circumferential-mode optical resonator for transverse-coupling thereto.
12. The resonant optical modulator of Claim 10, the modulator optical resonator being positioned axially relative to the circumferential-mode optical resonator for transverse-coupling thereto.
13. The resonant optical modulator of Claim 12, the circumferential-mode optical resonator comprising a fiber-ring optical resonator.
14. The resonant optical modulator of Claim 12, further including a spacer positioned between the circumferential-mode optical resonator and the modulator optical resonator.
15. The resonant optical modulator of Claim 10, the modulator optical resonator comprising a second circumferential-mode optical resonator.
16. The resonant optical modulator of Claim 10, the modulator optical resonator comprising a ring optical waveguide.
17. The resonant optical modulator of Claim 10, the circumferential-mode optical resonator and the modulator optical resonator being substantially co-planar.
18. The resonant optical modulator of Claim 10, the circumferential-mode optical resonator and the modulator optical resonator being substantially orthogonal.

19. The resonant optical modulator of Claim 10, the circumferential-mode optical resonator and the modulator optical resonator being substantially parallel.
20. The resonant optical modulator of Claim 1, the modulator optical component and the modulator control component being adapted for modulating, in response to the control signal, the level of optical loss of the modulator optical component.
21. The resonant optical modulator of Claim 20, the modulator optical component including an electro-absorptive material, the modulator control component including control electrodes adapted for applying an electronic control signal to the electro-absorptive material for modulating the level of optical loss of the modulator optical component.
22. The resonant optical modulator of Claim 21, the electro-absorptive material including a semi-conductor-based material.
23. The resonant optical modulator of Claim 21, the electro-absorptive material including a quantum well material.
24. The resonant optical modulator of Claim 21, the electro-absorptive material including an InGaAsP multi-quantum-well material.
25. The resonant optical modulator of Claim 21, the electro-absorptive material including a multi-layer reflector structure.
26. The resonant optical modulator of Claim 20, the modulator optical component including a non-linear optical material, the modulator control component including at least one optical component for transmitting an optical control signal to the non-linear optical material for modulating the level of optical loss of the modulator optical component.
27. The resonant optical modulator of Claim 1, the modulator optical component and the modulator control component being adapted for modulating, in response to the control signal, the level of optical signal power transfer by transverse-coupling between the circumferential-mode optical resonator and the modulator optical component.
28. The resonant optical modulator of Claim 27, the modulator optical component including an electro-optic material, the modulator control component including control electrodes adapted for applying an electronic control signal to the electro-optic material for modulating the level of optical signal power transfer by transverse-coupling between the circumferential-mode optical resonator and the modulator optical component.

29. The resonant optical modulator of Claim 28, the electro-optic material including a semi-conductor-based material.
30. The resonant optical modulator of Claim 28, the electro-optic material including a quantum well material.
31. The resonant optical modulator of Claim 28, the electro-optic material including an InGaAsP multi-quantum-well material.
32. The resonant optical modulator of Claim 28, the electro-optic material including a multi-layer reflector structure.
33. The resonant optical modulator of Claim 28, the electro-optic material including a polymeric material.
34. The resonant optical modulator of Claim 27, the modulator optical component including a non-linear optical material, the modulator control component including at least one optical component for transmitting an optical control signal to the non-linear optical material for modulating the level of optical signal power transfer by transverse-coupling between the circumferential-mode optical resonator and the modulator optical component.
35. The resonant optical modulator of Claim 1, the modulator optical component comprising a modulator optical resonator, the modulator optical resonator and the modulator control component being adapted for modulating, in response to the control signal, the resonant frequency of the modulator optical resonator.
36. The resonant optical modulator of Claim 35, the modulator optical resonator including an electro-optic material, the modulator control component including control electrodes adapted for applying an electronic control signal to the electro-optic material for modulating the resonant frequency of the modulator optical resonator.
37. The resonant optical modulator of Claim 36, the electro-optic material including a semi-conductor-based material.
38. The resonant optical modulator of Claim 36, the electro-optic material including a quantum well material.
39. The resonant optical modulator of Claim 36, the electro-optic material including an InGaAsP multi-quantum-well material.
40. The resonant optical modulator of Claim 36, the electro-optic material including a multi-layer reflector structure.

41. The resonant optical modulator of Claim 36, the electro-optic material including a polymeric material.
42. The resonant optical modulator of Claim 35, the modulator optical resonator including a non-linear optical material, the modulator control component including at least one optical component for transmitting an optical control signal to the non-linear optical material for modulating the resonant frequency of the modulator optical resonator.
43. The resonant optical modulator of Claim 1, the transmission optical waveguide comprising a transmission fiber-optic waveguide.
44. The resonant optical modulator of Claim 43, the transverse-coupling segment of the transmission optical waveguide including a fiber-optic-taper segment.
45. The resonant optical modulator of Claim 43, the transverse-coupling segment of the transmission optical waveguide including a side-etched segment.
46. The resonant optical modulator of Claim 43, the transmission fiber-optic waveguide including single-mode optical fiber.
47. The resonant optical modulator of Claim 43, the transmission fiber-optic waveguide including polarization-maintaining optical fiber.
48. The resonant optical modulator of Claim 47, the polarization maintaining optical fiber being elliptical-core optical fiber.
49. The resonant optical modulator of Claim 47, the polarization-maintaining optical fiber being "panda" optical fiber.
50. The resonant optical modulator of Claim 1, the circumferential-mode optical resonator comprising at least one fiber-ring resonator, the fiber-ring resonator including a transverse resonator segment integral with a resonator optical fiber between first and second segments of the resonator optical fiber and having a circumferential optical path length sufficiently different from a circumferential optical path length of an immediately adjacent portion of at least one of the first and second segments of the resonator optical fiber so as to enable the resonator segment to support a resonant optical mode near an outer circumferential surface of the fiber-ring optical resonator.
51. The resonant optical modulator of Claim 50, wherein the resonator segment is greater than about 10 μm in diameter.

52. The resonant optical modulator of Claim 50, wherein the resonator segment is greater than about 20 μm in diameter.
53. The resonant optical modulator of Claim 50, wherein the resonator segment is greater than about 100 μm in diameter.
54. The resonant optical modulator of Claim 50, wherein the resonator segment is less than about 2000 μm in diameter.
55. The resonant optical modulator of Claim 50, wherein the resonator segment is less than about 200 μm in diameter.
56. The resonant optical modulator of Claim 50, wherein the resonator segment is less than about 150 μm in diameter.
57. The resonant optical modulator of Claim 50, wherein a resonator segment is larger in radius than the immediately adjacent portion of at least one of the first and second segments of the resonator optical fiber, and the resonator segment radius exceeds the adjacent portion radius by a resonator segment step size.
58. The resonant optical modulator of Claim 57, wherein the step size is greater than about 0.1 μm.
59. The resonant optical modulator of Claim 57, wherein the step size is greater than about 0.5 μm.
60. The resonant optical modulator of Claim 57, wherein the step size is less than about 20 μm.
61. The resonant optical modulator of Claim 57, wherein the step size is less than about 1.5 μm.
62. The resonant optical modulator of Claim 50, wherein the resonator segment is greater than about 1 μm in width.
63. The resonant optical modulator of Claim 50, wherein the resonator segment is greater than about 2 μm in width.
64. The resonant optical modulator of Claim 50, wherein the resonator segment is less than about 10 μm in width.
65. The resonant optical modulator of Claim 50, wherein the resonator segment is less than about 4 μm in width.
66. The resonant optical modulator of Claim 50, the resonator optical fiber including at least one delocalized-optical-mode suppressor.

67. The resonant optical modulator of Claim 50, the transmission optical waveguide comprising a transmission fiber-optic waveguide, the transverse-coupling segment of the transmission optical waveguide including a fiber-optic taper segment, the resonator optical fiber including a fiber-optic-taper positioning-and-support structure for engaging the fiber-optic taper segment so as to transverse-couple the fiber-ring resonator and the fiber-optic taper segment.
68. The resonant optical modulator of Claim 67, the fiber-optic-taper segment being engaged by the fiber-taper positioning-and-support structure at a location axially displaced from an axial midpoint of the fiber-ring resonator so as to substantially reduce undesirable fiber-optic-taper-induced optical loss of the fiber-ring resonator.
69. The resonant optical modulator of Claim 67, the fiber-optic-taper segment being engaged by the fiber-taper positioning-and-support structure at a location radially displaced from an outer circumference of the fiber-ring resonator so as to substantially reduce undesirable fiber-optic-taper-induced optical loss of the fiber-ring resonator.
70. The resonant optical modulator of Claim 50, the transmission optical waveguide comprising a transmission fiber-optic waveguide, the transverse-coupling segment of the transmission optical waveguide including a fiber-optic taper segment of the transmission fiber-optic waveguide, the fiber-optic-taper segment being partially wrapped around the fiber-ring resonator near a portion of an outer circumference thereof.
71. The resonant optical modulator of Claim 70, wherein the spatial extent of the wrapped portion of the outer circumference of the wrapped fiber-ring resonator subtends an angle less than about 180°.
72. The resonant optical modulator of Claim 70, wherein the spatial extent of the wrapped portion of the outer circumference of the wrapped fiber-ring resonator subtends an angle greater than about 45°.
73. The resonant optical modulator of Claim 70, wherein the spatial extent of the wrapped portion of the outer circumference of the wrapped fiber-ring resonator is greater than about 10 μm.
74. The resonant optical modulator of Claim 70, wherein the spatial extent of the wrapped portion of the outer circumference of the wrapped fiber-ring resonator is greater than about 50 μm.

75. The resonant optical modulator of Claim 70, wherein the spatial extent of the wrapped portion of the outer circumference of the wrapped fiber-ring resonator is less than about 500 μm.

76. The resonant optical modulator of Claim 70, wherein the spatial extent of the wrapped portion of the outer circumference of the wrapped fiber-ring resonator is less than about 200 μm.

77. The resonant optical modulator of Claim 70, wherein the spatial extent of the wrapped portion of the outer circumference of the wrapped fiber-ring resonator yields about 90% transmission of a substantially resonant optical signal through the transmission fiber-optic waveguide in the absence of another optical element transverse-coupled to the fiber-ring resonator.

78. The resonant optical modulator of Claim 1, an over-coupled condition between the transmission optical waveguide and the circumferential-mode optical resonator corresponding to the higher operational optical transmission level, a substantially critically-coupled condition between the transmission optical waveguide and the circumferential-mode optical resonator corresponding to the lower operational optical transmission level.

79. The resonant optical modulator of Claim 1, a substantially critically-coupled condition between the transmission optical waveguide and the circumferential-mode optical resonator corresponding to the lower operational optical transmission level, an under-coupled condition between the transmission optical waveguide and the circumferential-mode optical resonator corresponding to the higher operational optical transmission level.

80. A method for controlling transmission of an optical signal through a transmission optical waveguide, the method comprising the step of applying a control signal to a modulator control component, the modulator control component being operatively coupled to a modulator optical component, the modulator optical component being positioned so as to be transverse-coupled to a resonant optical component, the resonant optical component including at least one circumferential-mode optical resonator, the resonant optical component being substantially resonant with the optical signal, the resonant optical component being transverse-coupled to the transmission optical waveguide, the modulator optical component and the modulator control component being adapted for modulating, in response to the applied control signal, at least one of i) a level of optical signal power

transfer by transverse-coupling between the circumferential-mode optical resonator and the modulator optical component, ii) a level of optical loss of the modulator optical component, and iii) a resonant frequency of the modulator optical component, the modulator control component, thereby enabling controlled modulation of a coupling condition between the transmission optical waveguide and the circumferential optical resonator, in turn enabling controlled modulation of a level of transmission of the optical signal through the transmission optical waveguide between a higher operational optical transmission level and a lower operational optical transmission level.

81. The method of Claim 80, the circumferential-mode optical resonator comprising a fiber-ring optical resonator.

82. The method of Claim 80, the transmission optical waveguide comprising an optical fiber having a fiber-optic taper segment adapted for transverse-coupling.

83. The method of Claim 80, the circumferential-mode optical resonator comprising a fiber-ring optical resonator, the transmission optical waveguide comprising an optical fiber having a fiber-optic taper segment adapted for transverse-coupling, the transmission optical waveguide being positioned so as to be transverse-coupled to the fiber-ring optical resonator at the fiber-optic taper segment.